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Technical and economic analysis of planned visual display terminal employment for the stock point logistics integrated communications environment (SPLICE).

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THESIS

TECHNICAL AND ECONOMIC ANALYSIS OF PLANNED VISUAL DISPLAY TERMINAL EMPLOYMENT FOR THE STOCK POINT LOGISTICS INTEGRATED COMMUNICATIONS ENVIRONMENT (SPLICE)

by

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June 1983

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The Stock Point Logistics Integrated Communications Environment (SPLICE) concept is designed to augment the existing Navy Stock Point and Inventory Control Point ADP facilities, in response to increasing demands for data processing, within the scope of a decentralized telecommunications environment. This thesis provides a critical review of the existing plan for employment of Visual Display Terminals (VDTs) within the SPLICE concept. VDT employment considerations are examined and alternative VDT employment options are presented. A technical and economic analysis is performed for both the planned and proposed alternative VDT equipment and employment options. Recommendations based on these findings are then presented.

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Technical and Economic Analysis of Planned Visual Display Terminal Employment for the Stock Point Logistics Integrated Communications Environment (SPLICE)

by

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ABSTRACT

The Stock Point Logistics Integrated Communications Environment (SPLICE) concept is designed to augment the existing Navy Stock Point and Inventory Control Point ADP facilities, in response to increasing demands for data processing, within the scope of a decentralized telecommunications environment. This thesis provides a critical review of the existing plan for employment of Visual Display Terminals (VDTs) within the SPLICE concept. VDT employment considerations are examined and alternative VDT employment options are presented. A technical and economic analysis is performed for both the planned and proposed alternative VDT equipment and employment options. Recommendations based on these findings are then presented.

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I. INTRODUCTION

A. GENERAL

The Stock Point Logistics Integrated Communications Environment (SPLICE) concept is designed to augment the existing Navy Stock Point and Inventory Control Point ADP facilities which support the Uniform Automated Data Processing System-Stock Points (UADPS-SP) [Ref. 1: p. 2-1]. The UADPS-SP was developed by the Navy Supply System Command (NAVSUP) to provide retail inventory management and financial control for Navy Supply Centers, Data Processing Service Centers and Naval Air Stations. Using Burroughs medium size systems, UADPS-SP has been shown to be inadequate for the interactive processing and telecommunications requirements of the approximately twenty application systems being developed presently within NAVSUP [Ref. 2: p. 2.1]. Additional functional capability and processing capacity will be required to support these requirements. To address these and other related problems, NAVSUP undertook the design, procurement, and implementation of SPLICE.

The major objectives of SPLICE are to provide an increased capability of visual display terminals with application logic and information retrieval from the systems data base; and, to standardize the multitude of interfaces

currently existing across approximately sixty supply sites. Another objective of SPLICE is to provide economical and responsive support capabilities for a decentralized telecommunications environment. A "foreground/background" concept will be implemented with SPLICE multiprocessor minicomputers, which will serve as a front-end processor for the Burroughs systems via a Local Area Network (LAN) interface, with the Burroughs computer providing the background processing functions for large file processing and report generation. SPLICE will be developed using a standard set of minicomputer hardware and software. This standardization is particularly important considering the fact that SPLICE will be implemented at some sixty different geographical locations, each having a different mix of application and terminal requirements.

Appendix A lists the application systems to be supported by both SPLICE and existing ADPE. Appendix B lists the host sites where SPLICE will support existing stock point computers, those remote SPLICE sites that will be supported through the Multiple Application Processing System (MAPS)--a system for remote job processing, the existing or expected applications systems within each site, and the number of visual display terminals on-site and those additionally projected for each site.

B. STATEMENT OF PROBLEM

The SPLICE concept involves the integration of the interactive processing and telecommunications requirements of all current and new projects operating within UADPS-SP. The multiple-site, decentralized concept includes various hardware and software upgrades which require sophisticated, state-of-the-art functional management within each LAN, yet present plans are to retain existing visual display terminal assets instead of planning a procurement for terminals of comparable SPLICE system state-of-the-art technology.

C. RESEARCH QUESTIONS

1. What are the present and proposed plans for visual display terminal equipment employment within SPLICE?

2. Does a technical and economic analysis of the planned visual display terminal employment for SPLICE substantiate consideration of alternative solutions?

D. THESIS OBJECTIVES

The intent of this thesis is to review the criterion used to base planning for visual display terminal employment for SPLICE; and, to provide a technical and economic analysis of the planned visual display terminal employment within the SPLICE concept. Alternative technological and/or economic solutions, to include specific visual display terminal

equipment and work environments, will be assessed and provided for appropriate consideration.

E. METHODOLOGY

A review of SPLICE project functional specifications and a survey of current literature pertaining to visual display terminals in a distributed processing/LAN environment was performed along with both telephone inquiries and personal interviews with Navy Stock Point and SPLICE Project personnel. Additionally, numerous commercial marketing representatives for government accounts were contacted for up-to-date specifications on visual display terminals currently available or in the production process. Research data received from these sources was then assimilated and an economic and technical analysis conducted in accordance with the procedures set forth in NAVDAC PUB 15 [Ref. 3].

F. SUMMARY OF FINDINGS

The findings of this research presents basically four policy alternatives for consideration. First, to continue as planned and use the Burroughs Peripheral Replacement procurement to purchase Burroughs terminals for immediate and long-term SPLICE requirements. The second alternative includes the implementation of the first alternative along with a Virtual Terminal Protocol (VTP) applied within each SPLICE LAN site. The third alternative would be to gradually

replace the Burroughs terminals with a more standard, state of-the-art visual display terminals which would complement the technical performance objectives and capabilities included within the SPLICE functional concept. The fourth, and final alternative includes implementation of the third alternative along with the VTP implementation within each SPLICE LAN site.

II. BACKGROUND

A. SPLICE VISUAL DISPLAY TERMINAL EMPLOYMENT OVERVIEW

The Naval Supply System has been plagued by inflexible terminal operations with respect to speed, code, format, editing capability, line discipline and command language. Furthermore, existing terminals are heavily dependent on inflexible vendor terminal control units and most of the terminals cannot be programmed for changing I/O requirements [Ref. 4: p. 44]. Yet, the SPLICE procurement contains no funds for terminal acquisition. NAVSUP currently plans to provide additional terminals for the Burroughs processors (Burroughs 3500/3700/4700/4800) for SPLICE employment via the Burroughs Peripheral Replacement procurement. This procurement contains a provision for purchasing an unspecified number of Visual Display Terminals (VDTs) functionally compatible with the current Burroughs MT983 VDTs, which employ the Burroughs poll-select line discipline.

The Burroughs Peripheral Replacement procurement will in effect make the Burroughs MT983 type terminal and the Burroughs poll-select line discipline a SPLICE "standard" which will potentially limit the larger technical objectives of SPLICE. This procurement plan thus seems incompatible with one of the UADPS-SP stated Support Objectives to "develop a modular telecommunications subsystem independent

of the current Burroughs medium systems which would simplify the eventual replacement of those systems at the end of their useful life," [Ref. 1: p. 2.2]. Furthermore, eventual replacement of the Burroughs system would leave the successor system(s) to contend with large numbers of Burroughs type terminals and the Burroughs terminal operation modes which could deprive the follow-on system(s) of capability maximization.

As identified previously, the Burrough terminals use a poll-select protocol system interface. Other existing protocols for terminals in the SPLICE environment include the UNIVAC polling protocols used at the Inventory Control Points and the asynchronous teletype-compatible protocols used on several minicomputers and at Stock Points and Inventory Control Points. With the integration of the interactive processing of SPLICE LAN's and networking via the Defense Data Network (DDN), SPLICE will have to adapt to a set of more sophisticated functional and complex protocols evolving from the developments of the DDN. The accommodation by SPLICE of these protocols will be considerably more difficult with large numbers of Burroughs type terminals in the system [Ref. 5: p. 9].

Procuring large numbers of Burroughs type terminals for employment within the SPLICE LAN concept will thus inhibit some aspects of the SPLICE technical performance sought and

ultimately incur greater implementation costs. Whether the advantages of the Burroughs terminals and their immediately available procurement offset these liabilities will be the subject of the technical and economic analysis presented in Chapter V of this thesis.

B. VISUAL DISPLAY TERMINAL EMPLOYMENT CONSIDERATIONS

It is becoming more apparent with each passing day and each system implementation that the selection of terminal equipment is an important stage in the design and operation of a system. With the marked improvement in cost-performance ratios of processors, the dominant cost in terminal based systems will be the cost of the terminals. However, the terminal will remain "the" interface the system presents to its human user. Thus, the efficiency of the entire system and the degree to which the system is exploited by its users will depend on the choice of terminals and the dialogue that takes place at the terminals. Even if the performance of a terminal suits its application perfectly, if it is ergonomically unsuitable the operator will not use the terminal efficiently and the system will never achieve its potential efficiency. Technical defects or capability limitations in terminals can also cause ill effects ranging from the slow and inaccurate operation of a potentially fast and precise system to substantial personnel rejection of a valuable and necessary job aid.

Another consideration in terminal employment is the transmission facilities provided and the importance of efficient use of these facilities. "The way to achieve this efficiency and, moreover, to perform the communications control processing most economically is now being shown to be through the use of processing power outside the main processor" [Ref. 6: p. 2]. The SPLICE concept includes employment of this technology by using minicomputers as front-end processor within the LAN's. This distribution of intelligence has also been integrated into concentrators and batch terminals and, more importantly in the context of this thesis, to terminals for some applications processing.

In considering the distribution of intelligence, what we are concerned with is what functions can be carried out by the terminals and what costs of the overall system can be minimized by the placement of certain functions at the terminals. Intelligent terminals take, for the most part, the form of what has become known as micro-computers. "These processors were mainly developed from process control machines and are eminently suitable for communications control" [Ref. 6: p. 4]. Intelligence outside the main processor can also contribute directly to security. As an example, a front-end processor with a disc store can ensure that no message is lost due to main processor failure. Correspondingly, if terminals with sufficient intelligence

are employed in a system, the use can be protected from any external failures since a terminal that incorporates a microprocessor can easily control a disc or magnetic tape store. A further cost-saving point is that the storage of the terminal processor can be used to enable the utilization of the maximum possible speed of the transmission line.

A final consideration for terminal employment pertains to the vexing question of whether hard copy is a continuing requirement: whether one needs to print or whether one can exist on soft copy from the terminal. With an increase of VDTs in the automated processing environment, maximization of soft copy review can be made of lengthy reports, files or similar documents rather than printing those same pages and hunting through them for specific items which may only consist of a few lines. This capability will obviously reduce the amount of paper dumping and promote efficiency in our daily operations. However, "in almost every conceivable instance, action commences (only) when a piece of paper confirms it" [Ref. 7: pp. 40-46]. This historical action medium, the hard copy, will remain a requirement into the foreseeable future. The question thus generated is will the VDTs employed have the capabilities to print just those pages, sections or lines (information blocks) needed to "commence action" with, or will entire documents have to be printed in order to get to the information needed? The

efficiencies of such a terminal capability require little selling, though the mechanics of doing so pose yet another question: should those specific information blocks be spooled off to the system's main printer(s), or possibly to one or more smaller, shared special purpose printers whose primary mission is to support internal organizational work processing and informational block retrieval? These questions will not be further addressed in this thesis, though consideration may be given for possible follow-on studies if their application appear justified.

With the SPLICE LAN, what is needed is something that can handle invoices, dispatch notes, stock record cards, ledger cards and many other items and, as the terminal is used by human beings of various skills, should provide extensive forms-handling facilities--all presented in a very user-friendly manner. This is all possible if the terminal is of either the smart or intelligent category; or, if a Virtual Terminal Protocol (VTP) is provided within the SPLICE LAN's with appropriate Network Virtual Terminal (NVT) translation for network data transfers.

C. INFERENCES

In summary, "SPLICE will create a telecommunications network independent of Burroughs equipment. The stock point networks today utilize a great variety of Burroughs terminals. This is due to the unique characteristics of the Burroughs

hardware architecture and the particular design of the Burroughs telecommunications polling sequences, which are one of the goals of SPLICE is to develop a network which will permit different vendors terminals to be utilized to interface with the Stock Point system. This will greatly facilitate the competitive procurement of computer terminals for Stock points and should ultimately result in lower terminal cost" [Ref. 8: pp. 32-35].

The preceding paragraph superficially provides the latitude to investigate the advantages and disadvantages of the planned SPLICE visual display terminal employment. In order to proceed, from the general to the specific, a methodology for economic and technical comparisons of terminals will be introduced in the following chapter, followed by a chapter devoted to the application of the VTP approach.

III. METHODOLOGY FOR VISUAL DISPLAY TERMINAL COMPARISON

A. ENVIRONMENT PERSPECTIVE

The SPLICE Local Area Network (LAN) will permit multiple terminal devices to be interconnected by coaxial or twisted pair cable for the purpose of sharing specified resources. Unlike local connections in a hierarchial network, where a dedicated cable is required for each device-to-device connection, the SPLICE LAN will provide a single cabling scheme which all devices will access. These connections will be established and terminated by network control software, and thus provide the capability for any device within the LAN of potentially communicating with any other device connected to the same cabling scheme and with remote devices via the DDN.

Like a hierarchial distributed data processing approach, the SPLICE LAN concept includes the distribution of intelligent data processing and related equipment to locations within the organization where applications are initiated, while allowing devices that are normally too expensive or not continuously required to be placed in each work area, to be shared by all. Non-intelligent devices, such as data or text entry stations, card devices and specialty printers, connected to the network also have the potential for interfacing with the system's processing capabilities,

providing even further distribution and sharing of resources [Ref. 9: pp. 162-166].

Basically, each processing device in the network, regardless of its size, is a separate entity that operates with complete independence of other LAN resources. The Burroughs system mainframe, in terms of network control functions, will generally be treated as a logical peer with other resources in the LAN, and does not become involved in communications occurring between other devices in the network. Accessing of other resources within the LAN occurs only when a specified application has requirements that cannot be fulfilled by the initiating device; thus, the distributed and resource sharing features of the SPLICE LAN are efficiently maximized.

B. FUNCTIONAL CATEGORIES AND CHARACTERISTICS

Visual Display Terminals (VDTs), also frequently referred to as either alphanumeric cathode-ray tube (A/N CRT) displays or just CRTs, fall into three overlapping categories: dumb, smart, and intelligent or user-programmable. These categories can be individually defined as follows:

> DUMB TERMINAL - are those terminals that offer only a limited number of functions.
>
> SMART TERMINALS - are those terminals that offer extended functions, such as formatted data entry and editing. A limited degree of programming may be provided, enabling format creation and parameter definition.

INTELLIGENT TERMINALS[1] - are those terminals featuring user-programmable support for at least one programming language, supported and documented for end-user program development. Additionally, these terminals include an operating system, I/O utilities, and one or more protocol cumulators.

Most all display terminals are microprocessor-controlled, as are most I/O devices. The microprocessor based programs (firmware) which control the basic terminal functions reside in ROM or PROM memory. ROM-resident programs control those features which are permanent and unchangeable, while PROM-resident programs implement the customized or modifiable features. The microprocessor firmware can also provide protocol emulation, defines the character/code sets to be generated by the keyboard and displayed on the screen, implements special features and sets control parameters [Ref. 10: p. 010-102].

The display medium for the majority of visual display terminals (VDTs)[2] manufactured today employ cathode-ray tubes

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[1]The majority of microcomputer systems/personal computers now being marketed in the United States possess the characteristics synonomous with intelligent terminals: capabilities such as protocol emulation for interactive and batch communications, multi-user/multi-tasking support, main processor memory, and expansion flexibility. Thus, reference to intelligent terminals will infer inclusion of microcomputers unless specifically stated otherwise.

[2]The author's choice in using VDT instead of the more commonly used CRT abbreviation to reference such terminal devices is for emphasis on the expansion of man-machine interaction encompassed within the SPLICE LAN concept.

(CRT). These devices provide high character capacity, flexibility (80 to 132 character line length), and are capable of displaying alphanumeric and numeric characters in virtually any format. Additionally, capabilities exist for many VDTs to provide a graphics character set, either provided by the vendor or user-programmable, for creating forms and report formats on the screen. There are also VDTs manufactured exclusively for interactive graphics or engineering graphics applications, but this paper will confine all future references to the alphanumeric type of display.

The combination of ergonomics and technology have provided VDT users with a variety of keyboard styles which are both more user-friendly and more job-oriented. The formerly most common styles were that of the typewriter and data entry, which contained numeric keypads in the top row and embedded in the alphabet part of the keyboards respectively. A more functional and frequently appearing style contains a numeric keypad located to the right of the main key group arranged in an adding-machine format. This latter style provides more efficient use for applications involving high volumes of numeric entries. The character/code set of the keyboard refers to the set of symbols that appear on the keytops and usually to the character codes (ASCII, EBCDIC, APL, etc.) generated by each

key depression. Another "friendly" feature is the ability for some keyboards to be located away (detachable) from the display. Though probably the most important feature a keyboard can possess is the availability of program function keys. This is a special feature where single keys represent commands for execution of a given system function, thus saving both time and potential input errors.

Communications between VDTs and the LAN host computer and/or front-end processor would be over a half duplex (transmission both directions, but not simultaneously) lines in a bus oriented LAN. The type of line discipline or communications protocol a VDT employs to transmit data varies from the ASCII asynchronous (transmission of data in irregular spurts) to synchronous (data transmitted in a steady stream) types, such as IBM's Binary Synchronous Communications (BSC) and Synchronous Data Line Control (SDLC), as well as various other communications protocols produced by other large mainframe vendors. The important point here is that the communications protocol or interface either provides clocking or accepts external clocking signals from the data set, and the VDT must transmit at a speed compatible with the communication environment in which it is used. Another characteristic variant of VDTs is the message format. This item refers to the way data is transmitted from the terminal: character-by-character, line-by-line, or in

blocks, and is important relative to the efficient use of communications facilities. Almost synonomous with the keyboards character/code set is the transmission code, the bit pattern of transmitted characters. ASCII is the industry and government standard, although EBCDIC is also widely used since it is commonly the code used with IBM equipment and plug-compatible peripherals.

In a multipoint operation (multiple-devices-per-line) such as that within the SPLICE LAN environment, each VDT must possess the abiity to distinguish a control message intended for it alone. This is necessary because, with a LAN, terminal communication will be in a broadcast mode rather than a dedicated mode. Polling, as currently used by existing Burroughs terminals, consists of sending a message to each VDT in turn, inviting the terminal to send data. Each VDT knows its own address, and since the front-end-processor includes the intended VDT's address in the poll message, it only responds to its own polls. There are, however, more efficient data link protocols, e.g. HDLC, available from various commercial vendors. Also relative to a multipoint operation is the terminal interface employed. The standard EIA0-RS-232-C specification is supported by most VDTs for attachment of each port to an external modem or remote communications device.

C. OPERATIONAL CHARACTERISTICS

Those features that a particular VDT provides a user that contributes "friendliness" to the man-machine interaction can appropriately be described as the operational characteristics, as opposed to the functional features described in the previous two sections of this chapter. What follows is a listing of VDT characteristics or specifications that the user, as opposed to the system designer, is apt to value as important for efficient job accomplishment. Included with each item listed, if needed, is a short definition for the purpose of clarity.

DISPLAY AREA SIZE - height and width in inches of the area of screen used to display characters.

SPOT DIAMETER - the diameter of the focused spot on the screen in mils.

BRIGHTNESS - in foot lamberts.

CHARACTER PER LINE

LINES

MAXIMUM MAIN PROCESSOR MEMORY - VDT user-accessable memory in bytes.

DISPLAY CAPACITY - the maximum number of display positions.

SCREEN ARRANGEMENT - the maximum number of displayable lines and displayable characters per line.

MAIN MEMORY CAPACITY - determines the upper limit of the size and complexity of programs that can be run by the VDTs system.

COLOR - characters or fields can be separated by color, which can also be used to identify conditions or types of data.

CHARACTER TYPEOVER - cursor placed over a previously typed character, a key pressed and the old character is replaced by the new one.

CHARACTER INSERT - the capability to insert a character into an existing line of displayed text, causing the remaining characters to shift right.

CHARACTER DELETE - the capability to delete a character from an existing line of displayed text, causing the remaining text to shift left.

LINE INSERT - the capability to insert a line of text into existing text.

LINE DELETE - the capability to delete a line of text from existing text.

SCROLL - the capability to move displayed lines of data up or down by one line as a new line is added or deleted.

ERASE - the capability to erase a character, line of text, message or complete screen display.

TABULATION - the capability to depress one key and cause the cursor to move a predetermined number of spaces to the right, or a predetermined number of lines up or down.

TYPE OF CURSOR - character underlined, blinking, etc.

SPLIT SCREEN - the capability where part of the screen can be used for variable data, while the remainder of the screen is used for fixed format.

PARTIAL TRANSMIT - the capability to transmit data in various parts of the screen without transmitting the entire screen.

AUDIBLE ALARM - a feature for alerting the user of an incoming message.

The user applied VDT characteristics listed above are not intended to be interpreted as an all inclusive compilation, but rather a complementary list of ergonomic and efficiency features for consideration in the comparison of VDTs for an economic and technical analysis.

D. COST FACTORS

The previous sections of this chapter have provided the basic technological, functional and operational characteristics, features for consideration in pursuing the effort to provide a technical and economic analysis of the planned VDT employment within the SPLICE concept. This section will address general cost factors which must be considered in the

context of both terminal-vs-terminal and cost-vs-performance tradeoffs.

As technological advances have driven down the costs of VDT hardware over the past few years, manufacturers have added more and more advanced features to their products while holding down, and in some cases even lowering, the price. Price, though, remains in proportion to capability, with dumb terminals carrying the lowest price tags while intelligent terminals are the most costly of the three categories.

However, in order to obtain a true economic comparison of VDTs, one has to look deeper than just capability listings or premature lifecycle cost analyses. For while intelligent terminals are growing in processing power and related capabilities, dumb terminals are attaining similar price/performance enhancements via technological improvements in communication access protocols for the computer/terminal link [Ref. 11]. Additionally, within each specific category of VDTs there are very significant price differences for terminals of similar capabilities. This latter observation will be illustrated in Chapter V within the context of the technical and economic analysis of VDT employment for SPLICE.

A final cost factor, which usually gets overlooked in most equipment comparison studies, is that of VDT energy consumption. As a simple example of the significance an item like energy consumption can make, assume a system

configuration included two VDTs with equal capabilities and cost, but were similar models from different manufacturers. Also assume that VDT "A" requires 60 watts input power and that VDT "B" requires 90 watts of input power. In a year, further assuming an "in-use" period of 10 hours per day per VDT and a 20 day work month, we would find that VDT "A" using 144 kilowatt-hours of energy and VDT "B" using 216 kilowatt-hours of energy. At a very conservative 15 cents per kilowatt-hour, that amounts to $21.60 and $32.40 a year in energy costs for VDT "A" and VDT "B" respectively. The $10.80 difference a year in energy costs may not initially cause any great concern or difference in possible decision for type or model of VDT to purchase, but considering a quantity of 2000 VDTs (approximately the number of existing SPLICE terminals), a quick calculation produces a $21,600 difference in energy costs per year. Of course these operational energy costs vary according to geographical location, but there is little chance that any location will realize any lowering of kilowatt-hour charges; however, the opposite case can almost be assured. What this illustration attempted to demonstrate is a requirement for considering operational energy costs in any equipment procurement decision in order to provide a complete lifecycle analysis of alternative choices [Ref. 12: pp. 55-57].

IV. VIRTUAL TERMINAL PROTOCOL APPROACH

A. ARCHITECTURE APPLICABILITY

SPLICE LAN's will communicate via the Defense Data Network (DDN) which, as previously stated, will require the SPLICE LAN's to accommodate an evolving set of functionally complex protocols [Ref. 5: p. 9]. This accommodation of network protocols provides an important set of services and an opportunity to incorporate a Virtual Terminal Protocol (VTP) approach within the SPLICE LAN's.

The DDN will be based on ARPANET technology [Ref. 13: p. 1] and thus require the support by network hosts of a complex set of protocols. The protocol architecture of the DDN is complicated by the dual goals of immediately supporting current applications via vendor protocols and using "standard" protocols where feasible [Ref. 14: p. 134]. Appendix C provides a summary of DDN/ARPANET protocols constituting the protocol architecture of the DDN, and includes a brief description of each protocol and its function. The two protocols which are of most importance for the implementation of the VTP are the TELNET (TN) protocol of the applications layer and the Transmission Control Protocol (TCP) of the transport layer.

TELNET is expected to be developed in conjunction with TCP and Internet Protocol (IP) developments for DDN

implementation and will provide Network Virtual Terminal (NVT) service while additionally supporting remote terminal access to hosts for Remote Job Entry (RJE). The TELNET protocol provides additional functions, but it is the provision of the NVT service which provides the capability for implementing the VTP approach while simultaneously being an integral part of the Terminal Management (TM) module residing within each SPLICE LAN [Ref. 15].

As an official DOD protocol standard, TCP, along with IP, was developed to provide essential military requirements of security, survivability, and reliability [Ref. 16: p. 114]. Of importance is the virtual circuit service provided by the TCP, and the network layer protocol interoperability and datagram feature of the IP. It is through the combined capabilities of the TELNET NVT protocol and the TCP-based architecture that the VTP approach can be realized. This virtualizing approach is what extends the SPLICE LAN concept into state-of-the-art technology.

B. VIRTUAL TERMINAL PROTOCOL CONCEPT

There are over a hundred vendors manufacturing VDTs in the United States today. Some of these vendors manufacture all three categories of VDTs (dumb, smart, and intelligent), while others specialize in only one category. Yet, no two terminals, of the same category and manufacturer, are identical. Standardization of terminals, both foreign and

domestic, occurs at a low level and is primarily concerned with electrical and mechanical properties. The VTP is an alternative approach to hardware standardization; historically, hardware standardization has been a slow process. The VTP concept grew out of network research projects such as the ARPANET in the United States, the CYCLADES network in France, the GMD network in West Germany, and the European Information Network (EIN) built for the European Economic Community [Ref. 17: p. 86]. This concept can basically be regarded as "an ideal terminal with a range of desirable features that can be handled by a typical applications program" [Ref. 18: p. 349] which prevents terminal characteristic incompatibilities by hiding terminal differences via protocols.

With the VTP approach, the terminal side of a connection maps the output (data) of its terminal into the TELNET-provided NVT format for transmission to the remote host. The remote host then maps the NVT format into its local form. The VTP provides the mapping of represented information (data structure) from the user's terminal, in contrast to the NVT protocol which maps the more physically defined characteristics of the terminal, e.g. character code, line length, page width, etc. This reduces the "m hosts x n terminals" problem to a "m x 1" problem [Ref. 4: p. 47], thus providing the accommodation for a variety of VDTs within and external to

the LAN while simultaneously enabling the maximum interoperability between terminals, processes, and terminal-process applications.

The NVT protocol would reside within the TM module as one of the primary terminal handling functions [Ref. 4: p. 47]. Since the NVT is at the highest level of resource-sharing protocols, a logical question might be how and where would the VTP be placed? There are two possible answers to this question: First, the VTP could be made a subset of the NVT within the TM module; or secondly, it could be placed within the terminal device itself if sufficient intelligence were possessed by the VDT. In the latter case, the TM module would have to sense the presence or lack of the VTP at the source/destination terminal. However, this method of implementation does not efficiently utilize the terminal's memory capacity or intelligence. Conversely, implementation of the VTP as a subset of the NVT within the TM module provides both consistency of protocol management (system vice user control) and non-interference (system consumption) of user's limited VDT capabilities.

The concept of the VTP implementation for application in SPLICE LANs is depicted in Figure 3-1. This graphical portrayal of the VTP implementation illustrates the interaction of three distinctly different categories of terminals with the TM module. Process 1 (P1) is a teletype

transaction and Process 2 (P2) is a related interaction with a dumb terminal. In both cases, the TM module exchanges characters with them in order to map commands and data between them via the VTP and the terminal interface (NVT) with the computer. Process 3 (P3), however, demonstrates the transaction between the TM module and an intelligent VDT with the VTP provided both internal to the device (dotted lines) and within the TM module.

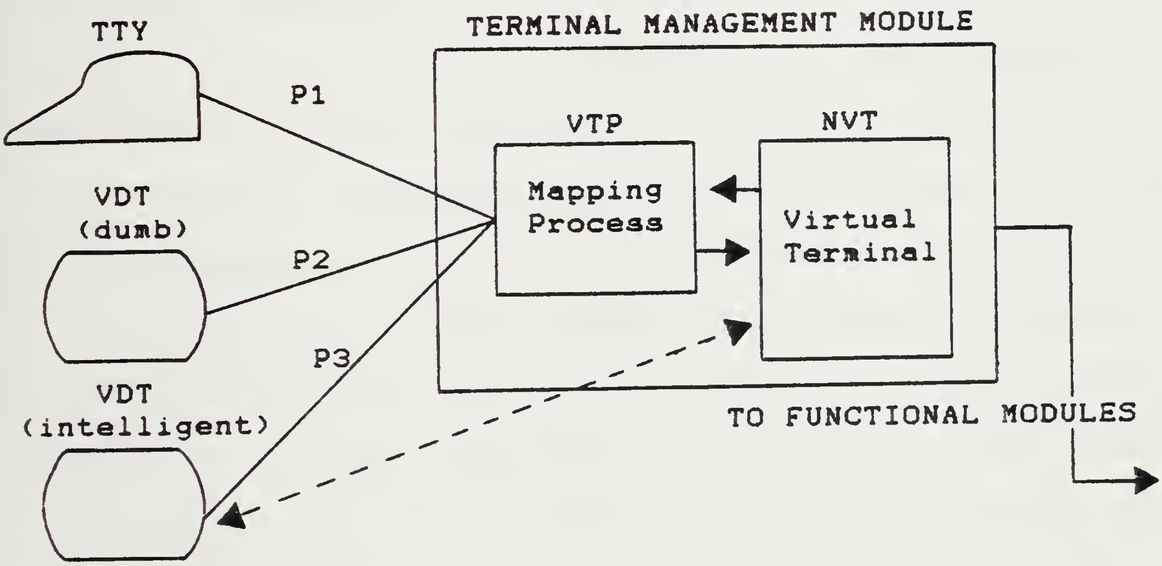

Figure 3-1. Virtual Terminal Protocol Implementation

The VTP concept just described is but one of two basic approaches to terminal protocols or TM module implementation. The other approach, Parametric Terminal Protocol (PTP), was not considered applicable for SPLICE LAN application in view of the lack of general functions provided by the Terminal Interface Processor (TIP) of ARPANET or the comparative Packet Assembler/Disassembler (PAD) for systems implementing a VTP or CCITT recommendations [Refs. 15: p. 24 and 17: p. 84].

C. FUNCTIONAL CHARACTERISTICS OF THE VIRTUAL TERMINAL PROTOCOL

The TELNET application of the VTP is based on three principles: the concept of NVT, the concept of a symmetrical view of terminals and processes, and the concept of negotiation or option negotiation. Each of these principles will be briefly discussed, the first two together, followed by shortcomings of the protocol and possible solutions.

For modeling purposes, TELNET's VTP concept consists of two NVT's connected back-to-back. Each user and, whether terminal or process, considers itself dealing with an NVT. The keyboard of one NVT is connected to the presentation unit or screen of the remote NVT, and vice versa. In a sense, control over each other's display medium is exchanged upon network connection, i.e. the keyboard of one and the display of the other belongs to one user. However, certain echo-

control mechanisms must occur first before any data sent to the NVT by a user or application is entered into the local presentation unit. One advantage of this model is that it allows the protocol to encompass the terminal-to-terminal, process-to-process, and terminal-to-process applications. It also allows a considerable amount of asynchrony to exist in the protocol while avoiding the delays and inefficiencies of attempting to synchronously share a data structure across a network.

The negotiation or optional negotiation mechanism permits the user to set terminal parameters to values other than the default values or to negotiate for more sophisticated options, e.g. screen size, full-duplex, etc. This symmetric model for negotiation has each end send an initial message completely describing what it wants concerning options. After receiving the message from its counterpart, each process computes the lowest common denominator of the parameter settings and initializes its data structure to use them. The symmetric model has clear advantages over an asymmetric protocol, where option negotiation consists of interations of option acceptance and rejection until negotiation of parameter capabilities are in agreement or until total rejection and connection termination. In addition to negotiating whether a specific option is to be in effect or not, the mechanism permits the specification, when

appropriate, of which side is to perform a specific function, e.g. the echo option to be done locally or remotely to the initiator of the negotiation.

The VTP is not without problems or shortcomings. The TELNET protocol used on the ARPANET was primarily designed to support scroll mode terminals, which neither have built in microprocessors nor any local editing capability. Thus when a key is depressed on one of these terminals, the corresponding character is sent over the line and, with some scroll mode terminals, displayed. As new lines are displayed, old ones just scroll upward. Further, the other two classes of terminals: page mode, those terminals which typically display 24 lines of 80 characters each and have some editing capability; and form mode or data entry terminals, which operate by essentially filling out a form, are not presently supported by the TELNET protocol [Ref. 19: pp. 421-423].

D. VIRTUAL TERMINAL PROTOCOL SUMMARY

Considering that the DDN will provide the TELNET protocol and TCP-based architecture protocols, and that the SPLICE LAN concept will include a great variety of existing terminals along with future terminals, a VTP approach appears quite logical and applicable for SPLICE LAN implementation as supported by References 4 and 15. It is important, however, to note that the VTP is not in competition with a particular category of terminals or with the selection of a standard

VDTs for SPLICE employment, but rather as a complementary and enhancing capability to the SPLICE LAN protocol architecture.

The design objectives of the SPLICE project clearly indicate a requirement for future growth while providing essential user services as quickly as possible. The VTP approach, with its inherent technological capabilities and growth potential, can more than adequately provide the services and performance demanded by the application systems slated to operate within the SPLICE concept.

V. TECHNICAL AND ECONOMIC ANALYSIS

A. PREFACE

The technical and economic analysis of the existing and planned Visual Display Terminal (VDT) employment, within the SPLICE Concept, to be presented in this chapter is derived from the Concept of Analysis as documented in NAVDAC PUB15 [Ref. 3]. The preceding chapters have provided the rudimentary data base from which the analysis will commence. Supplemental information will be inserted, and referenced, as the analysis progresses through the stages or elements of the process.

The concept of technical and economic analysis, though critically beneficial, is not without a certain amount of uncertainty. More economically than technically, the analysis involves assumptions and estimates of future events whose outcomes cannot be ascertained until they occur. Respectively, every effort will be made to complete the analysis with a systematic and unbiased approach. Further, since this thesis is directed specifically at the policy issue of VDT employment within the SPLICE LAN's, the analysis will be conceptually abridged or abstracted at times to address only those items of relative importance to VDT employment and the respective alternatives.

B. OBJECTIVE DEFINED

The objective of this chapter, the technical and economic analysis, and intent of this thesis, is to provide an analysis of the existing and planned VDT employment within the SPLICE Concept; and, to assess and compare the technical and economic consequences, tradeoffs, and alternatives thereof.

C. ASSUMPTIONS

1. The SPLICE Project will obtain procurement funds for additional and future VDT requirements.

2. That plant and personnel requirements will remain constant regardless of type or category of VDTs employed.

3. The specific quantity of VDTs required will remain constant regardless of type or category VDTs employed.

4. VDT utilization demand will increase, causing the VDT population to grow from the existing 2000 terminals to an estimated 16,000 by 1992.

5. A Virtual Local Area Network (VLAN) environment, consisting of: Virtual Terminal Protocol (VTP), Network Virtual Terminal (NVT), and generalized function modules, will be attainable.

6. A combination of VLAN and acquisition of state-of-the art VDTs will extend the useful life of same VDTs to eight years for SPLICE employment, even in face of the rapid technological advances being made in VDT development, from the point of procurement.

7. All new application systems developed after the installation of new equipment and protocols will use same without conversion.

D. ALTERNATIVES

1. Alternative 1: Current SPLICE VDT Employment Plan

The SPLICE VDT requirements for both immediate and long-term needs will be achieved by using the Burroughs Peripheral Replacements procurement to purchase Burroughs type terminals. Because the SPLICE procurement contains no funds for terminals, the Burroughs peripheral replacement procurement will allow for the purchase of large numbers of VDTs without initiating separate contract proceedings.

2. Alternative 2: Virtual Terminal Protocol (VTP Implementation

The existing SPLICE VDT employment plan will be enhanced through implementation of the VTP. A simulation of the VTP within the VLAN concept will be constructed by contractors, assisted by in-house personnel. Vendors bidding on the contract will be required to perform the simulation with an UADPS-SP application systems benchmark package and at their own expense. The contract will be awarded to the vendor demonstrating the best acceptable performance. The VTP implementation will be required to coincide with the SPLICE implementation schedule.

3. Alternative 3: Procure Standard, State-of-the-Art VDTs to Replace Existing Burroughs Terminals

The existing Burroughs type terminals will be gradually replaced with one or more standard, state-of-the art VDTs for SPLICE through a traditional competitive procurement. Vendors bidding on the contract will be required to demonstrate their terminal's capabilities concerning functional, operational, communications, and ergonomic characteristics. The contract will be awarded to the vendor(s) whose terminal(s) demonstrate the most capabilities for the least cost.

4. Alternative 4: Procure Standard, State-of-the-Art VDTs to Replace Existing Burroughs Terminals and Implement the VTP Within Each LAN

The existing Burroughs type terminals will be gradually replaced with one or more standard, state-of-the art VDTs for SPLICE employment simultaneously with implementation of a VTP within each LAN. Vendors bidding on the contract(s) will be required to demonstrate their terminal(s) capabilities concerning functional, operational, communications, and ergonomic characteristics; and (or, if a separate contract), to simulate a VTP within a VLAN environment operating with a UADPS-SP application systems benchmark package at their own expense. The contract(s) will be awarded to the vendor(s) demonstrating the best product(s) for the lowest cost(s).

E. COSTS AND BENEFITS

The costs for each alternative can be separated into nonrecurring costs and recurring costs, as can the benefits for each alternative be distinguished from the respective disadvantages. Nonrecurring costs are those costs which are made on a one-time basis; whereas, recurring costs are those costs which are incurred on a periodic basis throughout the project life. Benefits and disadvantages are self-explanatory. With this brief introduction, the following costs and benefits for each alternative are presented.

1. Nonrecurring Costs

The nonrecurring costs for the four alternatives vary only in the uniqueness of their respective capabilities offering. That is to say, such normal considerations under nonrecurring costs as computer room support equipment, construction, UPS upgrade, personnel requirements, and quantities of VDT'S needed will be identical for all alternatives. However, VDT values at termination, e.g. resale value, will vary between Alternatives 1 and 3 and at best only be estimated, based on historical and technological trends.

a. Alternative 1

The only nonrecurring costs that would arise from implementation of the current SPLICE VDT employment plan would be those incurred from the Burroughs peripheral

replacement procurement for the additional and long-term requirements.

b. Alternative 2

Nonrecurring costs for Alternative 2 would include those same costs identified with Alternative 1; plus, one-time costs of:

1. Drafting the VTP technical specifications
2. Drafting a Request for Proposal (RFP)
3. Defining selection criteria
4. Drafting the VTP implementation plan/schedule
5. Purchase of the selected vendor's product.

c. Alternative 3

Alternative 3's nonrecurring costs include:

1. Defining standards for dumb and intelligent VDTs to be employed
2. Drafting VDT technical specifications
3. Drafting a Request For Proposal (RFP)
4. Defining selection criteria
5. Determination of a VDT transition plan
6. Purchase of the selected vendor's products

d. Alternative 4

Nonrecurring costs for Alternative 4 would include those same nonrecurring costs of Alternative 3; plus, the one-time costs of:

1. Drafting the VTP technical specifications
2. Drafting the Request For Proposal (RFP)
3. Defining selection criteria
4. Determination of the VTP implementation plan/schedule
5. Purchase of the selected vendor's(s') product(s).

2. Recurring Costs

The recurring costs for all four alternatives will be identical except for: the additional software maintenance, which could be significant, associated with the VTP implementation of Alternatives 2 and 4; and, the reduction in general utilities associated with energy conservation improvements incorporated in most late types and models of VDTs. All other cost categories will generally approximate each other.

3. Benefits

a. Alternative 1

The primary benefit of Alternative 1 is the existence of the Burroughs Peripheral Replacement procurement option which provides a ready vehicle for the purchase of additional and long-term VDT requirements for SPLICE implementation. Additionally, it negates any further SPLICE environment studies concerning VDT requirements, technical or otherwise, and will not cause any potential changes to the SPLICE implementation schedule.

b. Alternative 2

One of the most important benefits of the VTP implementation is the "virtual standardization" of the existing Burroughs VDTs. As the proprietary polling sequence of the Burroughs terminals is not one of the industry standards (e.g. ASCII asynchronous, EBCDIC binary synchronous, etc.), the VTP assists in providing the extra architecture that will always be required to allow Burroughs VDTs to operate with non-Burroughs computer equipment. The VTP will also enhance the existing terminals capabilities while simultaneously providing a more "friendly" operating environment for the VDT user. The VTP, once established, would conceivably become a DOD standard due to its ability to allow flexible systems growth while enjoying the enhancements of the current technology.

c. Alternative 3

Alternative 3 provides an option which would allow the instruments of man-computer interaction, the VDT, to complement the technical performance objectives and capabilities of the SPLICE concept. The importance of a fully complementary ADP environment, especially within the framework of the SPLICE LAN Concept, is paramount to system interoperability, flexibility, and defined goals. Additionally, workloads will be able to be processed more rapidly and with more reliability and accuracy owing to the

improved efficiencies provided VDT users by currently available ergonomic features.

d. Alternative 4

The attributes of Alternative 2's VTP and Alternative 3's standardized, state-of-the-art VDT implementation are both combined in this policy option. These combined alternatives provide an enhanced SPLICE LAN environment which will extend both capabilities and equipment life cycles beyond those offered by the other alternatives.

4. <u>Disadvantages</u>

a. Alternative 1

The Burroughs proprietory polling sequence, as previously mentioned, is not an industry standard and its poll-select terminal access procedure is an inefficient I/O scheduling method. Additionally, the Burroughs terminal communications options (e.g. poll, select, multipoint, etc.) are unique to Burroughs stand-alone systems and will obstruct implementation of current technological protocols for LAN and internetwork integration. Most fundamental and important though is that the Burroughs VDTs range in price from one-third to one-half times more costly than competitor VDTs of comparable capabilities.

b. Alternative 2

The main disadvantage to the VTP implementation with Alternative 2, along with those disadvantages listed for

Alternative 1, is that this alternative requires funding for design and implementation as yet identified or validated and the added recurring expense of software maintenance. Some training of VDT users will also be required with implementation of the VTP in order to acquaint users with the enhanced capabilities provided by the VTP.

c. Alternative 3

The two disadvantages of replacing the Burroughs terminals with a standard, state-of-the-art VDT are that there will be some operations disrupted during the VDT replacement and training period and that funding of non-Burroughs terminals has not been identified as either required or validated.

d. Alternative 4

The disadvantages for Alternative 4 are those same disadvantages as identified for Alternative 3 and those VTP disadvantages identified in Alternative 2.

F. COMPARISON OF ALTERNATIVES

There are a variety of techniques which can be used to compare one alternative against another [Ref. 3: p. 2-7]. The benefits and costs of Alternatives 2 and 4 are more difficult to quantify than Alternatives 1 and 3 due to the variables of a protocol design and implementation. Consequently, this research presents only initial investment data that is readily supportable and makes only those

assumptions which follow current technological and economic trends which at least approximate reality.

As Alternatives 1 and 3 lack quantifiable data for recurring costs and savings at this point, if we assume these recurring costs and savings are approximately the same, differences in initial investments can be shown to be quite significant and correspondingly relative to begin Net Present Value calculations. Because the SPLICE VDT employment plan will include an implementation mix of both "dumb" and "intelligent" terminals, current cost and capabilities of Alternative 1 SPLICE representative Burroughs VDTs [Ref. 1: p. 2-10] and three representative optional choices for Alternative 3 are presented in Table 5-1, for dumb terminals, and Table 5-2, for intelligent terminals [Refs. 10 and 20]. Thus, Tables 5-1 and 5-2 provide at least an approximation of the Net Present Value of alternative choices for dumb and intelligent terminals of Alternatives 1 and 3 as follows:

Dumb Terminals		Intelligent Terminals	
Supplier/Model	Initial Investment	Supplier/Model	Initial Investment
Burroughs TD830	$3,289	Burroungs TC9300	$19,400
Westinghouse (C) W1642	$2,400	Cado 20/24 & 40/24	$17,570
C. Itoh CIT90	$1,295	Durango F-85	$ 8,795
Hazeltine Espirit III	$ 895	Ontel OP-1/15	$ 2,390

TABLE 5-1

DUMB TERMINALS FOR COMPARISON

SUPPLIER AND MODEL	BURROUGHS TD 830	WESTINGHOUSE CANADA MODEL W1642	C. ITOH CIT 90	HAZELTINE ESPRIT III
TERMINAL DESCRIPTION				
Stand-alone or cluster	Stand-alone	Either	Stand-alone	Stand-alone
Maximum displays/ controller	1	48	1	1
Transportability	No	No	No	No
IBM compatability	3275 opt.	IPARS	No	No
Teletype compatability	No	Opt.	Std.	Std.
Other compatability	Burroughs	Univac UTS 20, Uniscope 100	DEC VT101	---
DISPLAY PARAMETERS				
Display capacity, no. of chars.	2000	2000	1920	1920
Memory capacity, no. char./lines/ pages	2000 char. (4080)	80/25/1; multi opt.	80/24/1	1 page
Screen arrangement, lines x chars./line	25 x 80	24x80 plus status line	24 x 80	24 x 80
Screen area, diagonal, inches	11	12	12	12
Tilt/swivel screen	No	Opt.	No	Til std.
Total displayable symbols	128	94 ASCII+opt.	128 ASCII	128 ASCII
Symbol formation	5x7 dot matrix	5x7/7x9 dot	7x9 dot matrix	7x11 dot matrix

TABLE 5-1 (Cont'd.)

DUMB TERMINALS FOR COMPARISON

SUPPLIER AND MODEL	BURROUGHS TD 830	WESTINGHOUSE CANADA MODEL W1642	C. ITOH CIT 90	HAZELTINE ESPRIT III
Character phosphar	White	P31 green std.	P4 white stds.; P31 green/amber opt.	Green
Color capability	No	No	No	No
Programmable field/ char. highlighting via:				
Underline	Std.	Field std.	Std.	No
Blink	Std.	Field std.	Std.	Std.
Blank	Std.	Field std.	Std.	No
Bold	Std.	Std.	Std.	No
Reverse	Std.	Field opt.	Std.	Std.
Double size	Std.	No	No	No
Scroll	Up/down std.	Opt.	Up/down/jump/ sm.	No
Paging	Std.	Opt.	Opt.	No
Selectabale cursor blinking	Std.	Opt.	Std.	No
Addressable/readable cursor	Std.	Add. std.; Read opt.	Both std.	Both std.
Protected format	Std.	Opt.	Std.	Std.
Partial screen transmit	Std.	Std.	Std.	No
Split screen/windows	No	Opt.	3 std.	No
Tabulation	Fixed/var./reverse	Fwd./back std.	Fwd./back std.	Std.

TABLE 5-1(Cont'd.)

DUMB TERMINALS FOR COMPARISON

SUPPLIER AND MODEL	BURROUGHS TD 830	WESTINGHOUSE CANADA MODEL W1642	C. ITOH CIT 90	HAZELTINE ESPRIT III
Character insert/delete	Std.	Std.	Std.	No
Line insert/delete	Std.	Std.	Std.	Std.
Erase	Line/page std.	Char./line/ screen std.	Line/screen/ char./window	Line/screen std.
KEYBOARD PARAMETERS				
Style	Typewriter, data entry	Typewriter	Typewriter	Typewriter
Character/code set	128 ASCII	94 ASCII	128 ASCII	128 ASCII
Detachability	Std.	Std.	Std.	Std.
Program function keys	----	Up to 32 user-defined	16 std.	No
Numeric keypad	Opt.	Opt.	Std.	Std.
ANCILLARY DEVICES				
Serial printer, type and speed	Std.	30-60 cps impact	9600 bps	No
Line printer, type and speed	Std.	No	9600 bps	No
Composite video	No	No	No	No
Port for cust.-supplied devices	Std.	Std.	Std.	Std.
Other vendor-supplied devices	Audible alarm, ID card reader	Credit card reader, embedded numeric pad w/ calculator func.	----	----

TABLE 5-1 (Cont'd.)

DUMB TERMINALS FOR COMPARISON

SUPPLIER AND MODEL	BURROUGHS TD 830	WESTINGHOUSE CANADA MODEL W1642	C. ITOH CIT 90	HAZELTINE ESPRIT III
TRANSMISSION PARAMETERS				
Mode	Half-duplex	Half std.; full opt.	Half/full-duplex	Half/full-duplex
Technique	Async./sync.	Async./sync.	Asynchronous	Asynchronous
Communications protocol	Burr./BSC	Various opt.	ANSI/ASCII	TTY
Code	ASCII	ASCII	ASCII	ASCII
Speed, bits/second	Up to 38,400	Up to 9600	Up to 19,200	50-19,200
Format; character, line, or block	Char./block	Block	Char./line/block	Char./line/block
Multipoint operation (pollable/addr.)	Std.	Std.	No	No
Terminal interface	RS-232-C	Party line; RS-232-C opt.	RS-232-C, 20mA Std.	RS-232-C
Integral modem	No	No	No	NO
Integral acoustic coupler	No	No	No	No
PRICING AND AVAILABILITY				
Display station, 2-year lease, \$/mo.	143-179 (1 yr.)	—	—	—
Controller, 2-year lease, \$/mo.	—	—	—	—
Display station, purchase, \$	3,289-3,997	2,400	1,295	895

TABLE 5-1 (Cont'd.)

DUMB TERMINALS FOR COMPARISON

SUPPLIER AND MODEL	BURROUGHS TD 830	WESTINGHOUSE CANADA MODEL W1642	C. ITOH CIT 90	HAZELTINE ESPRIT III
Controller, purchase, $	---	425	---	---
Monthly prime-shift maint., $/mo.	---	Contact vendor	---	---
Date of announcement	---	5/80	1/82	6/82
Date of first production delivery	8/76	3/81	1/82	---
Display units installed to date	---	2300	---	---
Serviced by	Burroughs	Westinghouse Canada/RCA	Western Union	Hazeltine & Western Union
COMMENTS	Models include TD 831, TD 832, TD 833 & TD 834.	A base design CRT which can be supplied w/ customr firmware & I/O configure to meet specific customer requirements.	Lease plans available from authorized distributors.	

TABLE 5-2

INTELLIGENT TERMINALS FOR COMPARISON

SUPPLIER AND MODEL	BURROUGHS TC3900	CADO 20/24 & 40/24	DURANGO F-85	ONTEL OP-1/15
FUNCTIONAL CONFIGURATIONS				
Interactive keyboard/ printer terminal	Yes	Yes	Yes	Yes
Interactive keyboard/ display terminal	No	Yes	Yes	Yes
RJE/batch terminal	Yes	Yes	Yes	Yes
Multi-station shared processor system		Yes	Yes	Yes
Stand-along small bus./minicomputer		Yes	Yes	Yes
Component housing	Integral desk-type housing	Modular components	Integrated cabinetry keyboard	Integrated cabinet, detachable
COMPATABILITY				
IBM	2260	2780, 3780, 3741, 2770, BSC	Opt.; 2780/3780, 3270 BSC/SDLC	Opt.; 2780, 3780, SDLC/HDLC
Burroughs	Yes	No	---	Std.
Honeywell		No	---	No
Teletype		Std.	Opt.	Std.
Other compatibility		TWX, Telex, DDD, 8A1, X-on/X-off	---	---

TABLE 5-2 (Cont'd.)

INTELLIGENT TERMINALS FOR COMPARISON

SUPPLIER AND MODEL	BURROUGHS TC3900	CADO 20/24 & 40/24	DURANGO F-85	ONTEL OP-1/15
TRANSMISSION PARAMETERS				
Mode	Half duplex	Half/full duplex	Half/full duplex	Full duplex
Technique	Asynch./sync.	Async./sync.	Async./sync.	Async./sync.
Speeds, bits per sec.	1200 to 9600	Up to 9600	110 to 9600	Up to 50K
Code	ASCII	ASCII, EBCDIC, BAUD.	ASCII, EBCDIC	ASCII
Format character, line or block		Char., block	Char./line/block	Char./line/block/file
Communications interface	1 or 2 RS-232-C	RS-232-C	RS-232-C	RS-232-C, 20mA loop, 2-wire, or fiber optic
Communications protocol	Burr., BSC	BSC, ASCII	ASCII, BSC, SDLC	ASCII, BSC, SDLC
Multipoint operation		Opt.	Opt.	Std.
PROCESSOR/MAIN MEMORY				
Processor model/type		8085A	8085	8085A
Main memory capacity, bytes	48 to 50K	48K	65.5K to 196K	16K or 64K
Additional memory increment size, bytes	2K, 4K, 6K, 8K	416K	66.5K	16K
MASS STORAGE				
Diskette drive		Up to 3 1.2MB dskt.	Up to 4 drives	External diskette dr.

TABLE 5-2(Cont'd.)

INTELLIGENT TERMINALS FOR COMPARISON

SUPPLIER AND MODEL	BURROUGHS TC3900	CADO 20/24 & 40/24	DURANGO F-85	ONTEL OP-1/15
Disk drive		Up to 4 19MB cartr., 13MB or 26MB Winch.	One 12MB or 24MB Winchester drive	Up to 4 CDC drs.; up to 4 96MB Winch.
Half-inch magnetic tape drive	9 tr. tape dr.	---	No	Opt.
Cartridge tape drive		Opt.	No	---
Cassette tape drive	Up to 4 cassette drs	No	No	---
I/O DEVICES				
Keyboard character set/ style	ASCII, typewr.	ASCII typewr.	ASCII, typewr.	ASCII
Maximum number of work-stations per processor	1	4	5	1
Display, screen capacity lines x chars.	Opt. 8x32	25x80	16x64; 24x80	25x80
Serial printer, chars. per second	Std. 90, 120, 150 cps	150 cps	200 cps	Opt., up to 55 cps
Line printer speed, lines per minute	Opt.	220 Ipm	No	100 to 600 IPM
Other devices	Card rdr, punch, etc.	55 cps WP prin-ter	No	--
Port for customer-supplied I/O devices		Serial I/O	IEEE-488	---

TABLE 5-2 (Cont'd.)

INTELLIGENT TERMINALS FOR COMPARISON

SUPPLIER AND MODEL	BURROUGHS TC3900	CADO 20/24 & 40/24	DURANGO F-85	ONTEL OP-1/15
SOFTWARE SUPPORT				
Operating system		Multi-tasking	Real-time multi-user	Real-time multi-task
Main memory occupied by OS, bytes		16K	32K to 40K	2K to 8K
Programming languages	Assem. COBOL sub	CADOL II (BASIC)	BASIC	OPL, BASIC, COBOL
Utilities		File mgt., WP	File mgt.	Fil mgt., editor, debug
Applications programs		Financial, acctng.	Finan., word proc.	Acctg., order entry
Other software support		Electronic mail	Self-diagnostics	word pr., diag., emul., DB, data-com utility
Multiprogram/multi-task capability		Yes--4 concur. tasks	Yes--5 concur. tasks	Yes--64 tasks
Systems programs firm-ware-implemented		CADOL II com-piler	None	None
Software separately priced		Some	All	Some
PRICING AND AVAILABILITY				
Basic system	4K RAM, keyb., 90 cps prtr. forms handler, 1 cstte. tape drs.	48K processor, 2 dkst. drives 1 CRT/keyb., 1 DP printer	65.5K RAM, 1MB floppy, 100 cps printer, 1 CRT	15" CRT, detach-able keyb., 8K RAM< RS-232-C

TABLE 5-2 (Cont'd.)

INTELLIGENT TERMINALS FOR COMPARISON

SUPPLIER AND MODEL	BURROUGHS TC3900	CADO 20/24 & 40/24	DURANGO F-85	ONTEL OP-1/15
Purchase price, $	19,400	17,570	8,795	2,390 (qty. 100)
Monthly prime-shift maintenance, $	123	185	120	---
Monthly 2-yr. lease (incl. maint.), $	750	Contact vendor	---	---
Maximum practical system	50K RAM< keyb., 150 cps prtr., 2 comm., 4 cassette-tape drives	48K proc. 104MB disk, 2 wkstns. 1 DP prtr., 1 disk	131K RAM, 26MB disks, 200 cps printer, 5 CRT	Basic system, except 64K RAM
Purchase price,$	42,224	58,825	28,335	Contact vendor for pricing
Monthly prime-shift maintenance, $	164	560	266	---
Monthly 2-yr. lease (incl. maint.), $	1490 (1 yr.)	Contact vendor	---	---
Date of first delivery	1972	2/76	11/78	12/80
Terminal systems installed to date	---	See comments	3000	Over 20,000 (All mod.)
Serviced by	Burroughs	Cado	Durango, Dow Jones	Ontel, Syntonics
COMMENTS		Cado has installed over 8500 systes (all models) to date	Available with 800 XR dual mode letter quality printer	The OP-1/15 has new modern modular styling with a low-profile keyboard, and comes with an

The cost of the VTP design and implementation, though undetermined at this point, can be assumed to be the same for both Alternatives 2 and 4. Temporarily ignoring this nonrecurring cost, we can graphically display each alternatives' VDT Useful Life Value (ULV) on the vertical axis; and, the projected life cycle of the VDT, denoted by TIME in years, on the horizontal axis. Figure 5-1 illustrates this graphical approach for Alternatives 1 and 2. Though they both begin as equals, Alternative 1 gives way rather quickly of its usefulness (value) to improvements in technology; whereas, Alternative 2's usefulness declines in a more uniform manner.

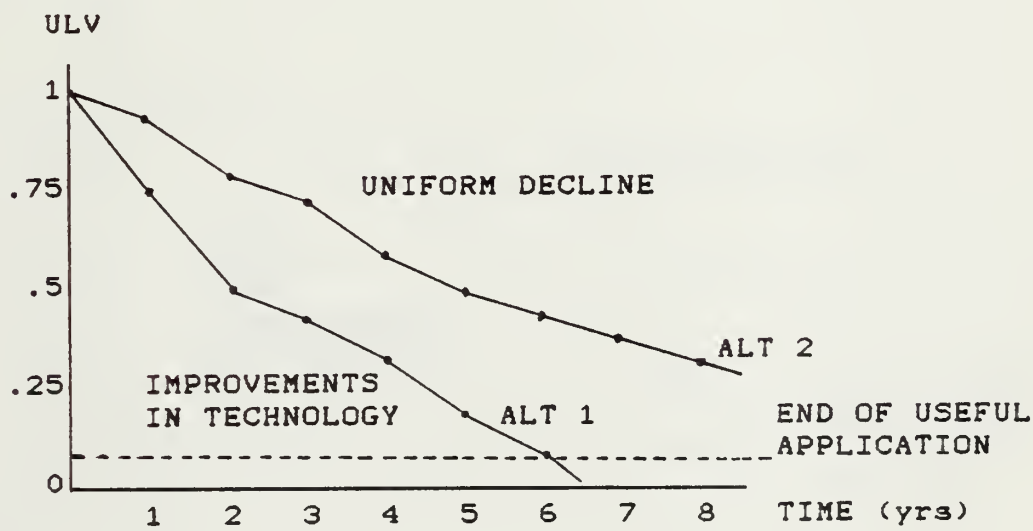

Figure 5-1. Graphical ULV Analysis for Alternatives 1 & 2

The more uniform decline of the ULV of Alternative 2, relative to Alternative 1's rapid demise in ULV, is a historical trend that has emerged within the last half decade due to improvements in technology and, of unique significance, standardization of protocols which (generally) bridge technology spans. Figure 5-2 depicts this same illustration for Alternatives 3 and 4. In this case though, both alternatives exhibit a more trivial decline in ULV than Alternatives 1 or 2. This is due to the combination of standardized, state-of-the-art protocols and VDTs of Alternative 4 and corresponding VDT qualities of Alternative 3.

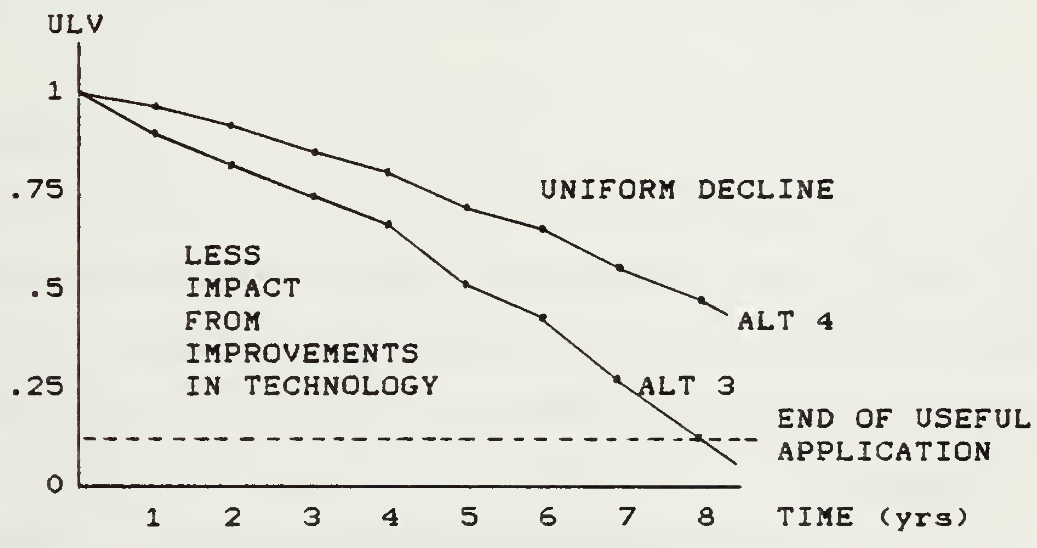

Figure 5-2. Graphical ULV Analysis for Alternatives 3 & 4

Though the data representations of both graphical illustrations for the alternatives are approximations of the emerging trends and not emperically documented as yet, they do provide another base from which to begin Net Present Value calculations for comparison of alternatives. For example, to compare the Net Present Values of Alternative 4 to Alternative 1, we could first calculate the Net Present Value of Alternative 4 by: SUMMING the nonrecurring costs of VDTs and design and implementation of VTP, and ADD this sum to the recurring cash-flows for software maintenance and operations TIMES the cumulative discount factor. Calculating the Net Present Value for Alternative 1, we simply SUM the nonrecurring costs of VDTs, and ADD this sum to the recurring cash-flows for operations TIMES the cumulative discount factor.

G. SUMMARY

This analysis has presented the culmination of the technical and economic trends and considerations identified in previous chapters. The liberties taken with the analysis processes were for brevity and to meet the objectives of this thesis in identifying potential cost savings and capabiliy enhancements for the SPLICE VDT employment plan.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. FINDINGS

The research and analysis of this thesis identified three viable alternative policy options for consideration by NAVSUP for SPLICE VDT employment, in addition to the planned utilization of the Burroughs Peripheral Replacement procurement option.

1. Planned SPLICE VDT Employment

The current SPLICE VDT employment plan specifies the use of the Burroughs Peripheral Replacement option as the vehicle to provide for the additional and future SPLICE VDT employment requirements.

2. Implementation of VTP

A VTP implementation would allow all planned and future applications to communicate with a variety of terminal devices and in a variety of ways in an efficient manner, while isolating the physical characteristics of the terminal devices from the various applications.

3. Standard, State-of-the-Art VDT Employment

Standardization forms the basis for efficient operation and improves the ability of the user to evaluate system performance. Though not all VDT categories have as yet conformed to or been identified with a nationally accepted standard, the S-100 bus structure has recently been

identified as the standard element for microcomputers. This standardization will naturally impact on intelligent terminals, since the distinction between them is blurred even to manufacturers.

4. Combined Standard, State-of-the-Art VDT Employment and VTP Implementation

A combination of standardized VDT employment and VTP implementation would provide the SPLICE LAN environments with the most versatile of possible alternatives.

B. ISSUES

1. Technology

The emergence of nationally accepted standards for microcomputers, and similarly capable intelligent terminals, would significantly improve user evaluation of VDTs under consideration for purchase and employment, while subsequently improving system performance evaluations. Coupled with the technological trends of increasing VDT capabilities, serious consideration of identifying and selecting alternative VDTs for SPLICE LAN employment appears warranted in order to take advantage of these recent developments.

2. Flexibility

The need for system flexibility and interoperability demanded by the integration of SPLICE LAN's and eventual DDN integration, plus the historical occurance of numerous unidentified user requirements, justifies further

investigation into the feasibility of a VTP implementation within each SPLICE LAN.

C. RECOMMENDATIONS

1. Redefine SPLICE VDT Employment Objectives

Redefine and specifically identify SPLICE VDT employment objectives and provide due consideration to the three alternative VDT employment options presented in view of the significant cost variances for VDTs of similar performance capabilities established.

2. Standardization

Utilize standard, state-of-the-art VDTs whose compatability and technology will provide the most efficient implementation and performance.

3. VTP Utility

Develop and implement a VTP within each SPLICE LAN. This would build into SPLICE the ability to flexibly provide for various terminal device communication access methods employed both now and in the future, while immediately enhancing the interoperability of existing terminal devices.

APPENDIX A

APPLICATION SYSTEMS SUPPORTED BY SPLICE

The following application systems, as identified by NAVSUP, represent the existing and new projects of UADPS-SP to be supported by the SPLICE Concept [Ref. 4].

ACRONYM	TITLE/BRIEF DESCRIPTION
APADE	Automation of Procurement and Accounting Data Entry: facilitates the administration, control and processing of all requisition and purchase requests done within the procurement component.
CAB	Centralized Accounting and Billing: to reduce cost and improve the accuracy and timeliness of Navy Stores accounting, financial inventory reporting and billing for centrally managed stores account material.
CLAMP	Closed Loop Aeronautical Management Program: Tracks and monitors the serialized control of repairable items that are high cost, high volume and applicable to essential weapon systems.
DOSS	Disk Oriented Supply System: A disk-oriented system for supply, financial management and record keeping functions for both Automated Ready Supply Stores and Independent Supply and Accounting Activities.

ACRONYM	TITLE/BRIEF DESCRIPTION
FAMMS	Fixed Allowance Management and Monitoring System: Provides a tracking and monitoring capability for fixed allowance items including depot-level repairables.
FIP (E&F)	Financial Improvement Project: Improves mechanization of current financial accounting system by conversion to a disk-oriented system.
IDA	Integrated Disbursing and Accounting: Establishes a Navy-wide Financial Information Processing System.
MAPS	Multiple Activity Processing System: Provides the capability of executing the same set of programs against a different set of files to support several activities on the same computer configuration and satellite RJE processing of same capabilities.
MISIL	Management Information System International Logistics: To advance the capability of the Navy to manage the International Logistics System.
NATDS	Navy Automated Transportation Data System: Improves the Navy Material Transportation Office (NAVMTO) in its traffic management, financial management and mission support roles.

ACRONYM	TITLE/BRIEF DESCRIPTION
NAVADS	Navy Automated Distribution System: An automated management system for material distribution and shipment planning.
NAVSCIPS	Navy Standard Civilian Payroll System: To standardize Navy payroll system for civilian personnel (replaces eight current systems).
OLA	On Line AUTODIN: Provides capability to connect both Stock Point and ICP systems directly to the nearest AUTODIN switching node (DDN vice AUTODIN when applicable).
OPTAR	Operating Target Accounting (TRIDENT): Combines features of SUADPS and current manual procedures with applicable portions of the UADPS-SP to provide streamlined method of OPTAR accounting.
PPMMS	Polaris/Poseiden Material Management System: To monitor requisitions and follow-up automatically, and to provide demand trends and analyze assets versus requirements.
RIP	Receipt Improvement Project: A receipt enhancement project to modernize receipt processing, utilizing VDTs as input devices and revising many of the current inputs and outputs.

ACRONYM	TITLE/BRIEF DESCRIPTION
(SUPSTARS (Central-lized)	Supply Selective Treatment and Review System: Provides selective inclusion of requisitions based upon UIC, Project Code, Distribution Code, etc., as well as storage and access to real-time data bases.
TRIDENT LDS	TRIDENT Submarine Logistics Data System: Provides direct interfacing of the Maintenance Management Data System component of TRIDENT LDS to the NSC Puget Sound Stock Point Computer Complex.

APPENDIX B

SITE CONFIGURATION ENVIRONMENT

The following provides a listing of SPLICE type processing and application systems to be implemented at each site, along with the number of VDTs on-site/additionally projected for each site.

SITE	TYPE	APPLICATION(S)	VDT(S)
NSC Norfolk, VA	Host	APADE, CLAMP, DOSS, IDA, E&F, MAPS, NAVADS, NATDS, OLA, OPTAR, RIP, TOPS	158/226
NSC San Diego, CA	Host	APADE, E&F, IDA, NAVADS, OLA, RIP, TOPS	47/250
NARDAC North Island, CA	Host	CLAMP, E&F, FAMMS, MAPS, OLA	3/20
NAS Miramar, CA	MAPS		
MCAS Yuma, AZ	MAPS		
NSC Charleston, SC	Host	APADE, E&F, IDA, NAVADS, OLA, PPMMS, RIP, TOPS	37/114
NSC Oakland, CA	Host	APADE, E&F, IDA, NAVADS, OLA, RIP, TOPS	55/226
NAS Brunswick, ME	MAPS		
NARDAC Alameda, CA	Host	CAB, CLAMP, E&F, FAMMS, MAPS, OLA, TOPS	2/20

SITE	TYPE	APPLICATION(S)	VDT(S)
NSC Pearl Harbor, HI	Host	APADE, DOSS, E&F, FAMMS, IDA, MAPS, OLA, NAVADS, PPMMS RIP, TOPS, OPTAR	33/105
NSC Lemoore, CA	MAPS		
NSC Puget Sound, WA	Host	APADE, E&F, FAMMS, IDA, MAPS, NAVADS, OLA, PPMMS, RIP, TOPS, TRIDENT	42/167
NARDAC Jacksonville, FL	Host	CLAMP, DOSS, E&F, FAMMS, MAPS, OLA, OPTAR, TOPS	5/21
SUBASE Pearl Harbor, HI	MAPS		
ASD Philadelphia, PA	Host	APADE, CAB, E&F, IDA, MISIL, TOPS	96/105
NARDAC New Orleans, LA	Host	DOSS, E&F, OLA TOPS	5
NAS Barbars Point, HI	MAPS		
NARDAC Pensacola, FL	Host	E&F, FAMMS, MAPS, OLA, TOPS	20/19
SPCC Mechanicsburg, PA	Host	APADE, CAB, (SUPSTARS, E&F	20/8
NARDAC Norfolk, VA	Host	E&F, FAMMS, MAPS, OLA	14/30
NAS Moffett, CA	MAPS		
MCAS Cherry Point, NC	Host	CLAMP, E&F, FAMMS, OLA	13/20
NATC Patuxent, MD	Host	E&F, FAMMS, MAPS, OLA, TOPS	12
MCAS ElToro, CA	Host	E&F, MAPS, OLA	24/15
NAS Cecil Field, FL	MAPS		

SITE	TYPE	APPLICATION(S)	VDT(S)
SWFPAC Silverdale, WA	Host	E&F, OLA, OPTAR, TRIDENT	4/15
NATC Point Magu, CA	MAPS		
NAS Oceana, VA	MAPS		
NSD Guam, GUAM	Host	E&F, FAMMS	10/6
NSD Subic Bay,PHILIPPINES	Host	E&F	2/12
NSD Yokosuka, JAPAN	Host	E&F	1
NSY Philadelphia, PA	MAPS		
SUBASE New London, CN	MAPS		
NAS Pensacola, FL	MAPS		
TRIDENT Refit Facility,WA	MAPS		
NAS Whidby Island, WA	MAPS		
NAS Lakehurst, NJ	MAPS		
NAY Portsmouth, VA	MAPS		
NAFE Indianapolis, IN	MAPS		
NAS Corpus Christie, TX	MAPS		
NAS Memphis, TN	MAPS		
MCAS Quantico, VA	MAPS		
NAS Key West, FL	MAPS		
NS Mayport, FL	MAPS		

APPENDIX C

DDN/ARPANET PROTOCOL ARCHITECTURE

The following provides a summary of DDN/ARPANET protocols which will constitute the protocol architecture of the DDN with respect to the layers of the International Standards Organization (ISO) model (Figure C-1). Further, a brief description of each protocol and its function, by layer, is provided for summary completeness [Ref. 12].

ISO LAYER	DDN/ARPANET PROTOCOLS
APPLICATION	TELNET, FIP, MAIL, RJE
PRESENTATION	
SESSION	TCP, (RTP)
TRANSPORT (INTERNETWORK)	TCP IP
NETWORK	1822 HOST-IMP; X.25; SIP
LINK	1822 LH/DH/VDH/HDH; HDLC LAPB; ADCCP
PHYSICAL	1822 LH/DH/ PHYSICAL; RS232C; MIL STD 188C

Figure C-1

1. DDN Higher Level Protocols. The DDN will support two classes of higher level protocols (Application, Presentation, and Session layers): those which operate in the vendor

architecture, and those which operate in the ARPANET/Internal architecture. The principle ARPANET/Internal higher layer protocols are the TELNET, File Transfer, and Mail Protocols. TELNET provides Network Virtual Terminal (NVT) service and remote access to hosts for Remote Job Entry (RJE) as its major attributes. The Mail and File Transfer protocols will be implemented, as required, to support the higher level of interoperability provided by those protocols.

2. DDN Transport Layer. The DDN will initially support two classes of transport protocols at this layer: vendor transport protocols and TCP. These protocols will be supported until such time as an accepted standard transport protocols, which meets all DOD requirements, is developed. TCP performs primarily transport functions and some session layer functions, e.g. reliable data transmission and connection of parties respectively.

3. DDN Internet Layer. The DDN will support the IP at the Internet layer for use in conjunction with the TCP transport layer and interface with other non-connection oriented transport protocols. The IP will be able to be used above the X.25, ARPANET Host-IMP, and SIP protocols. Additionally, IP will also be able to be used above a reserved set of logical channels with the X.25 virtual circuit, which will enable datagram transmission within the

internet (bottom three layers) while supporting virtual circuit-like service above.

4. <u>DDN Network Layer</u>. The DDN will support several different protocols at the Network Layer. These include: the ARPANET Host-IMP protocol, as described in BBN1822 and as 1822, which provides physical addressing for routine and, under development, logical addressing; X.25, which provide three types of service: switch virtual circuit, permanent virtual circuit, and datagram; and Segment Interface Protocol (SIP), which provides interface to those ADP systems which were developed to interface with SIP when it was the designated interface with the defunct AUTODIN II.

5. <u>DDN Link Layer</u>. The DDN Link Layer preferred protocol is HDLC LAP b as defined for use as a second level of the X.25 protocol, although the 1822 (Local Host -LH, Distant Host -DH, etc.) will also be supported, at least for an interim period. These layer protocols provide flow control and error control

6. <u>DDN Physical Layer</u>. The DDN Physical Layer will support all common standard physical interfaces, including both military standards such as MIL-STD-188C and commercial standards such as RS232-C. Additionally, the DDN will also support the 1822 LH and DH asynchronous bit serial interfaces. These layer protocols determine pin layout, voltage levels, etc., for the physical transmission of data.

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